Express Mail Label No. EM589154154US

UTILITY PATENT APPLICATION TRANSMITTAL
(Large Entity)

(Only for new nonprovisional applications under 37 CFR 1.53(b))

Docket No.
EN998082

Total Pages in this Submission
3

jc525 U.S. PTO 02/23/99

jc511 U.S. PTO 09/255894 02/23/99

TO THE ASSISTANT COMMISSIONER FOR PATENTS
Box Patent Application
Washington, D.C. 20231

Transmitted herewith for filing under 35 U.S.C. 111(a) and 37 C.F.R. 1.53(b) is a new utility patent application for an invention entitled:

DYNAMICALLY SWITCHING QUANT MATRIX TABLES WITHIN AN MPEG-2 ENCODER

and invented by:

Boice et al.

If a CONTINUATION APPLICATION, *check appropriate box and supply the requisite information:*

☐ **Continuation** ☐ **Divisional** ☐ **Continuation-in-part (CIP)** of prior application No.: _____

Which is a:

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Enclosed are:

Application Elements

1. ☒ Filing fee as calculated and transmitted as described below

2. ☒ Specification having 34 pages and including the following:

   a. ☒ Descriptive Title of the Invention

   b. ☐ Cross References to Related Applications *(if applicable)*

   c. ☐ Statement Regarding Federally-sponsored Research/Development *(if applicable)*

   d. ☐ Reference to Microfiche Appendix *(if applicable)*

   e. ☒ Background of the Invention

   f. ☒ Brief Summary of the Invention

   g. ☒ Brief Description of the Drawings *(if drawings filed)*

   h. ☒ Detailed Description

   i. ☒ Claim(s) as Classified Below

   j. ☒ Abstract of the Disclosure

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Application Elements (Continued)

3. ☒ Drawing(s) *(when necessary as prescribed by 35 USC 113)*
   a. ☒ Formal Number of Sheets **Eleven (11)**
   b. ☐ Informal Number of Sheets _____

4. ☒ Oath or Declaration
   a. ☒ Newly executed *(original or copy)* ☐ Unexecuted
   b. ☐ Copy from a prior application (37 CFR 1.63(d)) *(for continuation/divisional application only)*
   c. ☒ With Power of Attorney ☐ Without Power of Attorney
   d. ☐ *DELETION OF INVENTOR(S)*
   Signed statement attached deleting inventor(s) named in the prior application, see 37 C.F.R. 1.63(d)(2) and 1.33(b).

5. ☐ Incorporation By Reference *(usable if Box 4b is checked)*
   The entire disclosure of the prior application, from which a copy of the oath or declaration is supplied under Box 4b, is considered as being part of the disclosure of the accompanying application and is hereby incorporated by reference therein.

6. ☐ Computer Program in Microfiche *(Appendix)*

7. ☐ Nucleotide and/or Amino Acid Sequence Submission *(if applicable, all must be included)*
   a. ☐ Paper Copy
   b. ☐ Computer Readable Copy *(identical to computer copy)*
   c. ☐ Statement Verifying Identical Paper and Computer Readable Copy

Accompanying Application Parts

8. ☒ Assignment Papers *(cover sheet & document(s))*

9. ☐ 37 CFR 3.73(B) Statement *(when there is an assignee)*

10. ☐ English Translation Document *(if applicable)*

11. ☒ Information Disclosure Statement/PTO-1449 ☒ Copies of IDS Citations

12. ☐ Preliminary Amendment

13. ☒ Acknowledgment postcard

14. ☒ Certificate of Mailing
   ☐ First Class ☒ Express Mail *(Specify Label No.):* EM589154154US

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Accompanying Application Parts (Continued)

15. ☐ Certified Copy of Priority Document(s) *(if foreign priority is claimed)*

16. ☐ Additional Enclosures *(please identify below):*

Fee Calculation and Transmittal

CLAIMS AS FILED

For	#Filed	#Allowed	#Extra	Rate	Fee
Total Claims	29	- 20 =	9	x $18.00	$162.00
Indep. Claims	3	- 3 =	0	x $78.00	$0.00
Multiple Dependent Claims (check if applicable) ☐					$0.00
				BASIC FEE	$760.00
OTHER FEE *(specify purpose)*					$0.00
				TOTAL FILING FEE	$922.00

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☒ The Commissioner is hereby authorized to charge and credit Deposit Account No. 09-0457 (IBM) as described below. A duplicate copy of this sheet is enclosed.

- ☒ Charge the amount of $922.00 as filing fee.
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- ☐ Charge the issue fee set in 37 C.F.R. 1.18 at the mailing of the Notice of Allowance, pursuant to 37 C.F.R. 1.311(b).

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Express Mail No. EM589154154US

APPLICATION

FOR

UNITED STATES LETTERS PATENT

Attorney Docket No. EN998082

.0222222222222

INTERNATIONAL BUSINESS MACHINES CORPORATION

DYNAMICALLY SWITCHING QUANT MATRIX TABLES WITHIN AN MPEG-2 ENCODER

Technical Field

This invention relates in general to an apparatus and method for encoding digital visual images including spatial (intra-picture) and temporal (inter-picture) compression, that is reducing both redundancy within a picture and redundancy between pictures. Redundancy within pictures is reduced, or even eliminated, by the use of the discrete cosine transform, quantization, and variable length encoding. Redundancy between pictures is reduced, or even eliminated, through the use of motion vectors. This invention is more particularly directed to an enhanced encoder adapted to allow a user to switch and update quantization matrix tables in real time while encoding a stream of video data.

Background of the Invention

Within the past decade, the advent of world-wide electronic communications systems has enhanced the way in which people can send and receive information. In particular, the capabilities of real-time video and audio systems have greatly improved in recent years. In order to provide services such as video-on-demand and video conferencing to subscribers, an enormous amount of network bandwidth is required. In fact, network bandwidth is often the main inhibitor in the effectiveness of such systems.

In order to overcome the constraints imposed by networks, compression systems have emerged. These systems reduce the amount of video and audio data which must be

transmitted by removing redundancy in the picture sequence. At the receiving end, the picture sequence is uncompressed and may be displayed in real-time.

One example of a video compression standard is the Moving Picture Experts Group ("MPEG") standard. Within the MPEG standard, video compression is defined both within a given picture and between pictures. Video compression within a picture is accomplished by conversion of the digital image from the time domain to the frequency domain by a discrete cosine transform, quantization, variable length coding, and Huffman coding. Video compression between pictures is accomplished via a process referred to as motion estimation, in which a motion vector plus difference data is used to describe the translation of a set of picture elements (pels) from one picture to another.

The ISO MPEG2 standard specifies only the syntax of bitstream and semantics of the decoding process. The choice of coding parameters and tradeoffs in performance versus complexity are left to the encoder developers.

Users of MPEG encoders often desire the ability to change quantization matrix tables between pictures in a sequence of video data. For example, based upon a change in picture complexity from one frame to the next, a user may wish to modify the amount of quantization by changing the quantization matrix tables. To change matrix tables, sufficient time is needed to load the values of the new tables into the quantization unit of the encoder. As a result of the time required to load these values, the switching of matrix tables today cannot be accomplished in real time mode. The user is limited to pausing the

encoding, loading the tables and then continuing with the encode process.

In view of the above, and in order to establish commercial advantage, a novel design is desired wherein an encoder is adapted to allow dynamic (i.e., real time) switching of quantization matrix tables without interfering with the encode process.

Disclosure of the Invention

Briefly described, this invention comprises in one aspect an encoder for encoding a sequence of video data. The encoder includes storage for holding multiple sets of quantization matrix tables. A quantizer quantizes the sequence of video data using one set of the multiple sets of quantization matrix tables. Means are also provided for dynamically switching the quantizer from using the one set of quantization matrix tables to using another set of quantization matrix tables of the multiple sets of quantization matrix tables.

In another aspect, the invention comprises a method for encoding a sequence of video data. The method includes: providing storage for holding multiple sets of quantization matrix tables; quantizing the sequence of video data using one set of quantization matrix tables of the multiple sets of quantization matrix tables; and dynamically switching the quantizer from using the one set of quantization matrix tables to using another set of quantization matrix tables of the multiple sets of tables.

In a further aspect, an article of manufacture is provided which includes a computer program product

comprising computer usable medium having computer readable program code means therein for use in encoding a sequence of video data. The computer readable program code means in the computer program product includes: computer readable program code means for causing a computer to effect storing multiple sets of quantization matrix tables; computer readable program code means for causing a computer to effect quantizing the sequence of video data using one set of quantization matrix tables of the multiple sets of quantization matrix tables; and computer readable program code means for causing a computer to effect dynamically switching the quantizing from using the one set of quantization matrix tables to using another set of quantization matrix tables of the multiple sets of quantization matrix tables.

To restate, provided herein is an encoder and encode process adapted to allow a user to switch quantization matrix tables in real time while encoding a stream of video data. By providing the encoder with two sets of quantization matrix tables, for example, held in the quantization unit and the compressed store interface, significant new flexibility is attained. The flexibility to swap tables on the fly, for example, between default and custom matrix tables is provided, as well as the flexibility to modify selected tables within a given set of tables. Further, a user is provided with the flexibility to optimize picture quality based on the quantization matrix tables desired. While one set of matrix tables is being employed by the quantization unit, the encoder can be updating or modifying another set of quantization matrix tables, which after a few pictures can be switched to for use by the quantizer in quantizing the sequence of video data. This dynamic modifying of sets of tables and switching between

sets of tables provides significant commercial advantage to an encoder implemented in accordance with the principles of this invention.

Brief Description of the Drawings

The above-described objects, advantages and features of the present invention, as well as others, will be more readily understood from the following detailed description of certain preferred embodiments of the invention, when considered in conjunction with the accompanying drawings in which:

Fig. 1 shows a flow diagram of a generalized MPEG2 compliant encoder 11, including a discrete cosine transformer 21, a quantizer 23, a variable length coder 25, compressed store interface 27, an inverse quantizer 29, an inverse discrete cosine transformer 31, motion compensation 41, frame memory 42, and motion estimation 43. The data paths include the picture input 111, difference data 112, motion vectors 113, the picture output 121, the feedback picture for motion estimation and compensation 131, and the reconstructed picture 101. This figure has the assumptions that the i^{th} picture exists in Frame Memory or Frame Store 42, and that the $i+1^{th}$ picture is being encoded with motion estimation.

Fig. 2 illustrates the I, P, and B pictures, examples of their display and transmission orders, and forward, and backward motion prediction.

Fig. 3 illustrates the search from the motion estimation block in the current frame or picture to the best matching block in a subsequent or previous frame or picture.

Elements 211 and 211′ represent the same location in both pictures.

Fig. 4 illustrates the movement of blocks in accordance with the motion vectors from their position in a previous picture to a new picture, and the previous picture's blocks adjusted after using motion vectors.

Fig. 5 depicts one embodiment of a quantization unit to be modified in accordance with the principles of the present invention.

Fig. 6 depicts one embodiment of a quantization unit or quantizer 250 employing multiple sets of quantizer matrix tables in accordance with the present invention.

Fig. 7 shows various examples of combinations of sets of quant matrix tables which can be employed in accordance with the present invention.

Fig. 8a shows a flowchart of conventional encoder processing when new quant matrix tables are to be loaded.

Fig. 8b depicts a flowchart of encoder processing allowing dynamic switching between sets of matrix tables in accordance with the principles of the present invention.

Fig. 9 depicts one embodiment of a compressed store interface unit 401 which stores or has access to multiple sets of quantizer matrix tables in accordance with the present invention.

Fig. 10 depicts a flowchart of conventional compressed store interface processing.

Fig. 11 depicts a flowchart of compressed store interface processing in accordance with the principles of the present invention.

Best Mode For Carrying Out The Invention

The invention relates to scalable MPEG and HDTV compliant encoders and encoding processes. The encoding functions performed by the encoder include data input, spatial compression, motion estimation, macroblock type generation, data reconstruction, entropy coding, and data output. Spatial compression includes discrete cosine transformation (DCT), quantization, and entropy encoding. Temporal compression includes intensive reconstructive processing, such as inverse discrete cosine transformation, inverse quantization, and motion compensation. Motion estimation and compensation are the temporal compression functions. Spatial and temporal compression are repetitive functions with high computational requirements.

More particularly the invention relates to a processor for performing spatial and temporal compression including discrete cosine transformation, quantization, entropy encoding, motion estimation, motion compensation, and prediction, and even more particularly to a system for accomplishing spatial and temporal compression.

The scalable processor system has an I-frame only video encoder module with a Discrete Cosine Transform processor, a quantization unit, a variable length encoder, a FIFO buffer, and a compressed store interface. The system also includes

a second processor element, that is, an R-processor or Reconstruction processor with a reference memory interface, motion estimation and compensation capability, inverse quantization, and inverse discrete cosine transformation, and motion compensation means; and at least one third processor element for motion estimation. The system can be in the form of a single integrated circuit chip, or a plurality of integrated circuit chips, that is one for each processor, the I-frame video encoder module, the second processor element, and the third processor element. There can be one or more of the third processor units.

The first compression step is the elimination of spatial redundancy, for example, the elimination of spatial redundancy in a still picture of an "I" frame picture. Spatial redundancy is the redundancy within a picture. Because of the block based nature of the motion compensation process, described below, it was desirable for the MPEG-2 Standard to use a block based method of reducing spatial redundancy. The method of choice is the Discrete Cosine Transformation, and Discrete Cosine Transform coding of the picture. Discrete Cosine Transform coding is combined with weighted scalar quantization and run length coding to achieve still further levels of compression.

The Discrete Cosine Transformation is an orthogonal transformation. Orthogonal transformations, because they have a frequency domain interpretation, are filter bank oriented. The Discrete Cosine Transformation is also localized. That is, the encoding process samples on an 8x8 spatial window which is sufficient to compute 64 transform coefficients or sub-bands.

Another advantage of the Discrete Cosine Transformation is that fast encoding and decoding algorithms are available. Additionally, the sub-band decomposition of the Discrete Cosine Transformation is sufficiently well behaved to allow effective use of psychovisual criteria.

After transformation, many of the frequency coefficients are zero, especially the coefficients for high spatial frequencies. These coefficients are organized into a zig-zag pattern, and converted into run-amplitude (run-level) pairs. Each pair indicates the number of zero coefficients and the amplitude of the non-zero coefficient. This is coded in a Variable Length Code.

Motion compensation is used to reduce or even eliminate redundancy between pictures. Motion compensation exploits temporal redundancy by dividing the current picture into blocks, for example, macroblocks, and then searching in previously transmitted pictures for a nearby block with similar content. Only the difference between the current block pels and the predicted block pels extracted from the reference picture is actually compressed for transmission and thereafter transmitted.

The simplest method of motion compensation and prediction is to record the luminance and chrominance, i.e., intensity and color, of every pixel in an "I" picture, then record changes of luminance and chrominance, i.e., intensity and color for every specific pixel in the subsequent picture. However, this is uneconomical in transmission medium bandwidth, memory, processor capacity, and processing time because objects move between pictures, that is, pixel contents move from one location in one picture to a different location in a subsequent picture. A more advanced

idea is to use a previous or subsequent picture to predict where a block of pixels will be in a subsequent or previous picture or pictures, for example, with motion vectors, and to write the result as "predicted pictures" or "P" pictures. More particularly, this involves making a best estimate or prediction of where the pixels or macroblocks of pixels of the $i^{th}+1$ picture will be in the i^{th} picture. It is one step further to use both subsequent and previous pictures to predict where a block of pixels will be in an intermediate or "B" picture.

To be noted is that the picture encoding order and the picture transmission order do not necessarily match the picture display order. See **Fig. 2**. For I-P-B systems the input picture transmission order is different from the encoding order, and the input pictures must be temporarily stored until used for encoding. A buffer stores this input until it is used.

For purposes of illustration, a generalized flowchart of MPEG compliant encoding is shown in **Fig. 1**. In the flowchart the images of the i^{th} picture and the $i+1^{th}$ picture are processed to generate motion vectors. The motion vectors predict where a macroblock of pixels will be in a prior and/or subsequent picture. The use of the motion vectors instead of full images is a key aspect of temporal compression in the MPEG and HDTV standards. As shown in **Fig. 1** the motion vectors, once generated, are used for the translation of the macroblocks of pixels, from the i^{th} picture to the $i+1^{th}$ picture.

As shown in **Fig. 1**, in the encoding process, the images of the i^{th} picture and the $i+1^{th}$ picture are processed in the encoder 11 to generate motion vectors which are the form in

which, for example, the $i+1^{th}$ and subsequent pictures are encoded and transmitted. An input image 111 of a subsequent picture goes to the Motion Estimation unit 43 of the encoder. Motion vectors 113 are formed as the output of the Motion Estimation unit 43. These vectors are used by the Motion Compensation Unit 41 to retrieve macroblock data from previous and/or future pictures, referred to as "reference" data, for output by this unit. One output of the Motion Compensation Unit 41 is negatively summed with the output from the Motion Estimation unit 43 and goes to the input of the Discrete Cosine Transformer 21. The output of the Discrete Cosine Transformer 21 is quantized in a Quantizer 23. The output of the Quantizer 23 is split into two outputs, 121 and 131; one output 121 goes to a downstream element 25 for further compression and processing, such as to a run length encoder; and then to another element 27, i.e., a compressed store interface, for processing before transmission. The other output 131 goes through reconstruction of the encoded macroblock of pixels for storage in Frame Memory 42. In the encoder shown for purposes of illustration, this second output 131 goes through an inverse quantization 29 and an inverse discrete cosine transform 31 to return a lossy version of the difference macroblock. This data is summed with the output of the Motion Compensation unit 41 and returns a lossy version of the original picture to the Frame Memory 42.

As shown in **Fig. 2**, there are three types of pictures. There are "Intra pictures" or "I" pictures which are encoded and transmitted whole, and do not require motion vectors to be defined. These "I" pictures serve as a source of motion vectors. There are "Predicted pictures" or "P" pictures which are formed by motion vectors from a previous picture and can serve as a source of motion vectors for further

pictures. Finally, there are "Bidirectional pictures" or "B" pictures which are formed by motion vectors from two other pictures, one past and one future, and can not serve as a source of motion vectors. Motion vectors are generated from "I" and "P" pictures, and are used to form "P" and "B" pictures. "P" and "B" pictures are also referred to as "Nonintra" or "Inter" pictures.

One method by which motion estimation is carried out, shown in **Fig. 3**, is by a search from a macroblock 211 of an i^{th}+1 picture throughout a region of the previous picture to find the best match macroblock 213 (211' is the same location as 211 but in the previous picture). Translating the macroblocks in this way yields a pattern of macroblocks for the $i+1^{th}$ picture, as shown in **Fig. 4**. In this way the i^{th} picture is changed a small amount, e.g., by motion vectors and difference data, to generate the $i+1^{th}$ picture. What is encoded are the motion vectors and difference data, and not the $i+1^{th}$ picture itself. Motion vectors translate position of an image from picture to picture, while difference data carries changes in chrominance, luminance, and saturation, that is, changes in color and brightener.

Returning to **Fig. 3**, we look for a good match by starting from the same location in the i^{th} picture 211' as in the $i+1^{th}$ picture. A search window is created in the i^{th} picture. We search for a best match within this search window. Once found, the best match motion vectors for the macroblock are coded. The coding of the best match macroblock includes a motion vector, that is, how many pixels in the y direction and how many pixels in the x direction is the best match displaced in the next picture. Also encoded is difference data, also referred to as the "prediction error", which is the difference in chrominance

and luminance between the current macroblock and the best match reference macroblock.

The operational functions of an MPEG2 encoder are implemented in three basic devices: an I or Intra device, an R or Reconstruction or Reference device, and an S or Search device. The functions are partitioned according to application needs, silicon size, tools and design complexity, and performance. The I, R and S devices are described in detail in a co-pending, commonly assigned United States patent application by Murdock et al., entitled "Macroblock Bit Regulation Schemes For Video Encoder," Serial No. 08/859,544, the entirety of which is hereby incorporated herein by reference.

As noted briefly above, the present invention is directed to providing MPEG encoders with the capability to dynamically change quantization matrix tables at a picture boundary while encoding a stream of video data. Conventionally, quantizer 23 (**Fig. 1**) and compressed store interface 27 (**Fig. 1**) reference one set of matrix tables during the encoding of a stream of video data. The matrix tables are a set of two or four tables, each table containing 64 values. In 4:2:0 mode, two tables are used, one for intra blocks and the other for non-intra blocks. In 4:2:2 mode, four tables are used, one for intra luminance blocks, one for non-intra luminance blocks, one for intra chrominance blocks, and the last for non-intra chrominance blocks. To change a set of matrix tables between picture boundaries, enough time is needed to load 256 values into the encoder. As a result of this time requirement, switching of matrix tables is conventionally not done in real-time mode. A user is limited to pausing the encoder, loading the tables and then continuing the encoding.

Fig. 5 presents one embodiment of a conventional quantizer 220 of an MPEG encoder. Quantizer 220 is responsible for quantizing the DCT coefficients from the DCT processor and then sending the coefficients to variable length coder (VLC) 25 and inverse quantization (IQ) 29 (**Fig. 1**). Quantization involves scaling the DCT coefficients in a two-step process per MPEG Standard. The DCT coefficients are initially input to an "individual quantization of DCT coefficients" logic block 230, which quantizes each coefficient based on its relative location within the subject block of the macroblock. This quantization is made with reference to a weight value stored in quantizer matrix tables 232 in the quantizer unit 220. The quantizer processes one block of a macroblock at a time. There are six blocks in a 4:2:0 macroblock and eight blocks in a 4:2:2 macroblock. Thus, the first step is a quantization of each coefficient based on its relative location in the 8x8 block of the 16x16 macroblock.

The second quantization step is scaling all coefficients in the macroblock. This "quantization of scaled DCT coefficients" 234 comprises an overall quantization which is set by the processor in consideration, for example, of the bit rate. This scaling is made with reference to a selected stepsize or MQUANT 236. The stepsize can be adjusted depending upon whether the bit rate is above or below a target bit rate. Output again is to the variable length encoder 25 (**Fig. 1**).

Pursuant to the present invention, quantization unit 220 is modified to include memory space for multiple sets of quantizer matrix tables. **Fig. 6** depicts one example of a quantizer 250 in accordance with this invention. Again,

quantizer 250 is responsible for quantization (i.e., scaling down) of DCT coefficients. DCT coefficient input from the discrete cosine transform unit is received in individual quantization block 262 where each coefficient is scaled down based on a scaling factor dependent on the coefficient's coordinates in the block.

Memory is provided within quantizer 250 for holding at least a first set of quantizer matrix tables 263 and a second set of quantizer matrix tables 264. Set 263 comprises one complete set of quantizer matrix tables (four tables per set in 4:2:2 format) used by the individual quantization logic 262, while set 264 also comprises one complete set of quantizer matrix tables for use by the individual quantization logic 262. By way of example, selection of set 263 or set 264 can be controlled through use of a 1 bit table set register 261 within the quantizer. After individual quantization of DCT coefficients, all coefficients are scaled by logic 266 using the same scale factor or stepsize 268. Output from quantizer 250 is again to the variable length coder and the inverse quantizer.

As noted, in accordance with the principles of this invention, the quantization unit has storage capacity to hold at least two complete sets of quant matrix tables. (Note that if desired, greater than two sets of quantizer matrix tables could be provided within a quantizer in accordance with the present invention.) In 4:2:2 mode, each set consists of an intra luminance matrix table, a non-intra luminance matrix table, an intra chrominance matrix table, and a non-intra chrominance matrix table.

Fig. 7 depicts four examples of various matrix table sets which could be employed in a quantizer in accordance

with this invention. Matrix table set 1 270 comprises a first complete quantizer matrix set of four tables, and matrix table set 2 280 comprises a second complete quantizer matrix set of four tables. In these examples, default intra luminance table 271 is a default table from the MPEG standard for intra luminance. Default non-intra luminance table 272 is a default table from the MPEG standard for non-intra luminance. Default intra chrominance table 273 is a default table from the MPEG standard for intra chrominance, while default non-intra chrominance table 274 is a default table from the MPEG standard for intra chrominance. In matrix table set 2 280 of case 1, multiple user defined custom tables are provided. Specifically, custom intra luminance table 275 comprises a user defined custom table for intra luminance, custom non-intra luminance table 276 is a user defined custom table for non-intra luminance, custom intra chrominance table 277 is a user defined custom table for intra chrominance, and custom non-intra chrominance table 278 is a user defined custom table for non-intra chrominance. As shown in the various cases of **Fig. 7**, any combination of default and custom quant matrix tables can be employed pursuant to this invention within the at least two different matrix table sets 270 & 280.

In one embodiment, during encoder chip power-on reset and initialization, the default quant matrix tables per MPEG standard are loaded into both sets of tables within the quantization unit, i.e., sets 263 & 264 of **Fig. 6**. Also during initialization, the user has the ability to load over any default quant matrix tables with custom quant matrix tables, referred to herein as user specified custom quant matrix tables. Either an entire set of default tables (i.e., four tables) can be overwritten or only one or more of the default tables can be customized. In any case, the

complete set of tables is referred to as custom requiring them to be outputted in the encoded bitstream before use. The user may customize either or both sets of matrix tables in the quantization unit. Before the picture encoding starts, microcode will set register 261 (**Fig. 6**) in the quantization unit to indicate which set of matrix tables to use based on user input.

While encoding a picture stream, the user has the ability pursuant to this invention to dynamically switch between the two sets of quant matrix tables at picture gaps. For example, the picture stream may be coming up to a scene change where one set of matrix tables may provide optimal compression of detail over the other set. The user can therefore instruct the microcode to set the register in the quantization unit to switch to the other set of tables during the picture gap, i.e., when no picture is currently being processed through the quantization unit. Because the other set is already loaded within the encoder, i.e., within the quantizer, the switch can be accomplished in real time between pictures without stopping the encoder. In addition, with two sets of tables, the user can load a new set of tables into the unused set while the encoder is processing the stream using the other set. Again, there is no need for stopping the encoder, and this also can be accomplished in real time. In one embodiment, the encoder may incorporate a hardware translation of the matrix coefficients for the quantizer unit. Such a hardware translation would significantly reduce time required to load a matrix table. For example, the user can load one full quantization matrix table on the encoder command stack and have it loaded into the quantizer unit during a single picture gap. Using this technique, all four matrix tables in a set can be loaded within four picture gaps.

Fig. 8a presents one embodiment of processing flow within a standard encoder when quant matrix tables are to be switched, and **Fig. 8b** depicts process flow in accordance with the principles of the present invention. In the conventional encoder process of **Fig. 8a**, the encoder is initialized 301 at power on reset by loading microcode, encoding parameters and quantizer matrix tables. After initialization, picture encoding commences 302 and proceeds to encode each picture of a stream of video data 303. At a picture gap, i.e., at a point between pictures in the stream of video data, processing determines whether the user wishes to switch matrix tables 304. Again, between pictures there is no picture data or coefficients flowing through the quantizer. If the user wishes to switch the quant matrix tables, then encoding stops or pauses 305 to allow sufficient time to load the new matrix tables 306. The new matrix tables are loaded either from a user or from an external storage which has previously been setup by the user. Thereafter, encoding can be recommenced 302 and the next picture encoded 303. At the next picture gap 304, if the user does not wish to switch matrix tables, processing inquires whether encoding of the stream of video data has been completed 308. If no, then the next picture is encoded 303. Otherwise, the process is complete since there are no more pictures to encode 309.

In contrast, the encoding flow of **Fig. 8b** presents a simplified process in that once two or more sets of quantizer matrix tables are held within the quantizer, the encoder can switch between matrix tables in real time 310 if a user wishes to switch the tables at a picture boundary. Again, there is no need to stop the encode process since switching is accomplished in real time simply by changing a bit within, for example, a register within the quantizer.

Further, in accordance with the principles of the present invention the encode process could switch back to the first set of quant matrix tables, or could load a further set of quant matrix tables into the storage space for the first set while using the second set of matrix tables.

As noted above, the compressed store interface unit 27 (**Fig. 1**) in accordance with the present invention also has access to both sets of quantization matrix tables. **Fig. 9** depicts one embodiment of a compressed store interface unit 401 in accordance with this invention. Unit 401 outputs the compressed bitstream from a merge headers and coefficient data logic block 402. Logic 402 is a hardware area that combines start codes and macroblock data to form the output bitstream. The logic receives as input coefficient data or macroblock data from the variable length coder, as well as header information from the processor, which indicates which MPEG start codes are to be included in the compressed bitstream. Logic 402 also has access to the two sets of quantizer matrix tables 403 & 404, which in one embodiment, are held in storage within the compressed store interface 401. Quantizer matrix tables set 403 comprises one complete set of quantizer matrix tables used in the individual quantization step. Again, in one example there are four tables per set. Quantizer matrix tables set 404 also contains one complete set of quantizer matrix tables.

When the matrix table set selected is a custom set, the compressed store interface will place the matrix tables into the output bitstream. Since the table sets are preferably held at interface 401, there is no time delay needed to pass the matrix table values to the compressed store interface for including in the output bitstream. The compressed store interface can select which tables from the set are to be

included if all four tables are not used in the encoding. Again, the swapping of tables and including of custom tables in the output bitstream is all accomplished dynamically, i.e., in a real time mode without stopping the encode process.

One embodiment of the compressed store interface process is described in greater detail in United States patent no. 5,526,054 by Greenfield et al., entitled "Apparatus For Header Generation," the entirety of which is hereby incorporated herein by reference. In this patent, there is described a shared data buffer that can contain either a quantizer matrix table or coefficient data. There is also a section of the header buffer that contains the templates for the quant matrix extension start code. The conventional templates are as follows:

Command	Data	Output
010	Extension Start Code	000001B5 hex
001	Quant Matrix Extension Start Code ID	3 hex
011	Load Intra Matrix	'1' + 64 byte table
011	Load non-Intra Matrix	'1' + 64 byte table
011	Load Chrominance Intra Matrix	'1' + 64 byte table
011	Load Chrominance non-Intra Matrix	'1' + 64 byte table

Microcode controls which tables are sent by writing a '1' to the header buffer address that contains the template for a table that is to be sent. The command code "011" tells the hardware to send the "next" 64 bytes from the shared data buffer. Therefore, matrix tables must conventionally be loaded into the buffer in the order they are to be sent. Once the processor has selected which tables are to be sent it issues a "ship headers" command to the compressed store interface. The compressed store interface hardware then byte-aligns the output bitstream and

outputs the quant matrix extension start code ("000001B53" hex followed by up to 4 sets of - a valid bit and 64 bytes of table data).

For the present invention, an additional buffer is added in the compressed store interface unit that can store up to eight quant matrix tables (i.e., 2 sets of four tables). The tables are loaded using a three bit "table ID" which is used as an index into the buffer. Microcode uses the same "table ID" when it selects which tables are to be included in the bitstream. This advantageously allows the encoder to manage two full sets of quant matrix tables without having to stop and reload the tables.

Fig. 10 depicts one embodiment of standard compressed store interface processing, while **Fig. 11** depicts compressed store processing employing two sets of matrix tables in accordance with the principles of the present invention. Beginning with **Fig. 10**, the encoder is initialized, for example, at power on reset by loading microcode and encoding parameters, as well as loading default quantizer matrix tables 501. The encoder outputs a sequence header from the compressed store interface 502, which is followed by the picture start code 503. Processing then determines whether custom matrix tables are to be employed 504, and if no, a picture is encoded 505. The encoder next determines whether the complete stream of video data has been encoded 506, and if yes, outputs a sequence end header 507.

If encoding the stream of video data has not been completed, then processing inquires whether it is time to repeat the sequence header 514. The sequence header again tells a decoder whether to use the default quant matrix tables. If custom matrix tables are desired, then the quant

matrix extension must be output again with repeating of the sequence header. If the sequence header is not to be repeated at this picture boundary, then processing determines whether the custom matrix tables are to be changed 508. Again, changing of the custom matrix tables is user specified. If no, then the next picture start code 503 is output and the picture is encoded 505.

If the custom matrix tables are to be changed, then processing outputs a sequence end header from the compressed store interface 509 and stops the encoder 510. In this conventional flow the user has thus instructed the encoder to stop, which is necessary in order to load the new matrix tables. The user must also block uncompressed video input to the encoder. The custom matrix tables are loaded 511 and the encoder is restarted to allow passing of uncompressed video input to the encoder 512, after which a sequence header code is output 502 from the compressed store interface.

Finally, if the sequence header is to be repeated 514, and custom matrix tables are also being switched, then processing outputs the end sequence code 509 and proceeds as described above. Otherwise, the next sequence header code 502 is output, followed by picture start code 503.

In the compressed store processing flow of **Fig. 11**, the encoder is initialized 501, followed by output of a sequence header from the compressed store interface 502 and a picture header 503. Processing determines whether custom matrix tables are to be employed 504. If yes, then the quantizer matrix extension start code 513 is output from the compressed store interface. Again, this code includes any custom matrix tables. The picture is then encoded 505,

after which processing determines whether the complete stream of video data has been encoded 506. If yes, a sequence end header is output from the compressed store interface. Otherwise, processing determines whether it is time to repeat the sequence header 514, and if yes, the sequence header code is output 502, followed by the next picture start code 503. If the sequence header is not to be repeated, processing determines whether the custom matrix tables are to be changed 508. If no, then the compressed store interface simply outputs the next start picture code 503 and the encoder encodes the picture 505. If the custom matrix tables are to be changed, then from inquiry 508 the compressed store interface outputs a picture header 503, followed by the quant matrix extension start code 513, again including any new custom matrix tables.

The following scenario will demonstrate the flexibility of an encoder implemented in accordance with the principles of the present invention. The encoder is initialized and default tables are loaded into set 1 and set 2 of the quant matrix tables. The user loads a custom matrix table into set 2 and begins encoding. At a picture boundary, the user issues the command to switch from set 1, which is a default set, to set 2, which as noted, comprises custom tables. After a few pictures, the user switches back to the default matrix tables and begins loading a new set of custom tables into set 2 at picture boundaries of the stream of video data. After a few pictures, the user switches back to set 2 and starts loading another custom matrix set into set 1. During this whole scenario, the encoder is processing data in a real time mode, i.e., without stopping or pausing.

With the encoder's use of two sets of quantization matrix tables, significant new flexibility is provided. The

flexibility to swap tables on the fly between default and custom matrix tables is provided, as well as the flexibility to modify only selected tables within a given set. Further, the user is provided with flexibility to optimize picture quality based on the quantization matrix tables desired.

The present invention can be included, for example, in an article of manufacture (e.g., one or more computer program products) having, for instance, computer usable media. This media has embodied therein, for instance, computer readable program code means for providing and facilitating the capabilities of the present invention. The articles of manufacture can be included as part of the computer system or sold separately.

Additionally, at least one program storage device readable by machine, tangibly embodying at least one program of instructions executable by the machine, to perform the capabilities of the present invention, can be provided.

The flow diagrams depicted herein are provided by way of example. There may be variations to these diagrams or the steps (or operations) described herein without departing from the spirit of the invention. For instance, in certain cases, the steps may be performed in differing order, or steps may be added, deleted or modified. All of these variations are considered to comprise part of the present invention as recited in the appended claims.

While the invention has been described in detail herein in accordance with certain preferred embodiments thereof, many modifications and changes therein may be effected by those skilled in the art. Accordingly, it is intended by the appended claims to cover all such modifications and

changes as fall within the true spirit and scope of the invention.

Document Page

Claims

1. An encoder for encoding a sequence of video data, said encoder comprising:

storage for holding multiple sets of quantization matrix tables;

a quantizer for quantizing said sequence of video data using one set of quantization matrix tables of said multiple sets of quantization matrix tables; and

means for dynamically switching said quantizer from using said one set of quantization matrix tables to using another set of quantization matrix tables of said multiple sets of quantization matrix tables.

2. The encoder of claim 1, wherein said means for dynamically switching comprises means for switching said quantizer from using said one set of quantizer matrix tables to using said another set of quantizer matrix tables at a picture boundary of said sequence of video data.

3. The encoder of claim 2, wherein said means for switching said quantizer at said picture boundary comprises means for switching from said one set of quantizer matrix tables to said another set of quantizer matrix tables without delaying encoding of said sequence of video data by said encoder.

4. The encoder of claim 3, wherein said means for dynamically switching further comprises a table set register within said quantizer adapted to control said switching of said quantizer from said one set of quantization matrix tables to said another set of quantization matrix tables.

5. The encoder of claim 1, wherein at least one table of said one set of quantization matrix tables comprises a default quantization matrix table pursuant to MPEG standard.

6. The encoder of claim 1, wherein multiple tables of said one set of quantization matrix tables comprise default quantization matrix tables pursuant to MPEG standard.

7. The encoder of claim 1, wherein at least one table of said another set of quantization matrix tables comprises a user's custom quantization matrix table.

8. The encoder of claim 1, wherein multiple tables of said another set of quantization matrix tables comprises a user's custom quantization matrix tables.

9. The encoder of claim 1, wherein each set of quantization matrix tables of said multiple sets of quantization matrix tables comprises at least one quantization matrix table, each quantization matrix table of said at least one quantization matrix table comprising one of a default quantization matrix table pursuant to MPEG standard or a user's custom quantization matrix table.

10. The encoder of claim 1, wherein each set of quantization matrix tables comprises an intra luminance table and a non-intra luminance table.

11. The encoder of claim 1, wherein each set of said multiple sets of quantization matrix tables comprises an intra luminance table, a non-intra luminance table, an intra chrominance table, and a non-intra chrominance table.

12. The encoder of claim 1, further comprising means for dynamically changing quantization matrix tables of a presently unused set of quantization matrix tables of said multiple sets of quantization matrix tables while quantizing said sequence of video data using said one set of quantization matrix tables or said another set of quantization matrix tables.

13. The encoder of claim 1, further comprising a compressed store interface for outputting a compressed bitstream produced by said encoder from said sequence of video data, said compressed store interface including means for dynamically outputting a quantization matrix extension start code in said compressed bitstream upon switching of said quantizer from using said one set of quantization matrix tables to using said another set of quantization matrix tables.

14. The encoder of claim 13, wherein said compressed store interface further comprises storage for also holding said multiple sets of quantization matrix tables.

15. The encoder of claim 13, wherein said means for dynamically outputting said quantization matrix extension start code comprises means for outputting said another set of quantization matrix tables in said compressed bitstream upon said quantizer switching from said one set of quantization matrix tables to said another set of quantization matrix tables.

16. The encoder of claim 13, wherein said means for dynamically outputting comprises means for outputting said quantization matrix extension start code in said compressed bitstream without pausing said encoding of said sequence of video data by said encoder.

17. The encoder of claim 13, further comprising means for changing quantization matrix tables in a presently unused set of said multiple sets of quantization matrix tables while said quantizer is quantizing said sequence of video data using said one set of quantization matrix tables or said another set of quantization matrix tables.

18. A method for encoding a sequence of video data, said method comprising:

providing storage for holding multiple sets of quantization matrix tables;

quantizing the sequence of video data using one set of quantization matrix tables of said multiple sets of quantization matrix tables; and

dynamically switching said quantizing from using said one set of quantization matrix tables to using another set of quantization matrix tables of said multiple sets of quantization matrix tables.

19. The method of claim 18, wherein said dynamically switching comprises switching said quantizing from using said one set of quantizer matrix tables to using said another set of quantizer matrix tables at a picture boundary of said sequence of video data.

20. The method of claim 19, wherein said switching of said quantizing at said picture boundary comprises switching from said one set of quantizer matrix tables to said another set of quantizer matrix tables without delaying encoding of said sequence of video data.

21. The method of claim 18, wherein at least one table of said one set of quantization matrix tables comprises a default quantization matrix table pursuant to MPEG standard or a user's custom quantization matrix table.

22. The method of claim 18, wherein at least one table of said another set of quantization matrix tables comprises a default quantization matrix table pursuant to MPEG standard or a user's custom quantization matrix table.

23. The method of claim 18, wherein each set of said multiple sets of quantization matrix tables comprises an intra luminance table and a non-intra luminance table.

24. The method of claim 18, wherein each set of said multiple sets of quantization matrix tables comprises an intra luminance table, a non-intra luminance table, an intra chrominance table, and a non-intra chrominance table.

25. The method of claim 18, further comprising dynamically changing quantization matrix tables of a presently unused set of quantization matrix tables of said multiple sets of quantization matrix tables while quantizing said sequence of video data using said one set of quantization matrix tables or said another set of quantization matrix tables.

26. The method of claim 18, further comprising producing a compressed bitstream employing a compressed store interface, said producing comprising dynamically outputting a quantization matrix extension start code in said compressed bitstream upon said switching from said one set of quantization matrix tables to said another set of quantization matrix tables.

27. The method of claim 26, wherein said dynamically outputting comprises outputting said quantization matrix extension start code in said compressed bitstream without pausing said encoding of said sequence of video data.

28. The method of claim 26, further comprising changing quantization matrix tables in a presently unused set of said multiple sets of quantization matrix tables while quantizing said sequence of video data using said one set of quantization matrix tables or said another set of quantization matrix tables.

29. An article of manufacture comprising:

a computer program product comprising computer usable medium having computer readable program code means therein for use in encoding a sequence of video data, said computer readable program code means in said computer program product comprising:

computer readable program code means for causing a computer to effect storing multiple sets of quantization matrix tables;

computer readable program code means for causing a computer to effect quantizing the sequence of video data using one set of quantization matrix tables of said multiple sets of quantization matrix tables; and

computer readable program code means for causing a computer to effect dynamically switching said quantizing from using said one set of quantization matrix tables to using another set of quantization matrix tables of said multiple sets of quantization matrix tables.

* * * * *

DYNAMICALLY SWITCHING QUANT MATRIX TABLES WITHIN AN MPEG-2 ENCODER

Abstract of the Disclosure

A digital video encoder is presented adapted for dynamically switching between sets of quantizer matrix tables without pausing encoding of a stream of video data. Two or more sets of quantizer matrix tables are held at the encoder's quantization unit and compressed store interface for dynamically switching between sets of quant matrix tables at a picture boundary of the sequence of video data, i.e., without stopping encoding of the sequence of video data. Further, while one set of matrix tables is being employed to quantize the stream of video data, the encoder can be updating or modifying another set of quantization matrix tables, again without stopping encoding of the sequence of video data.

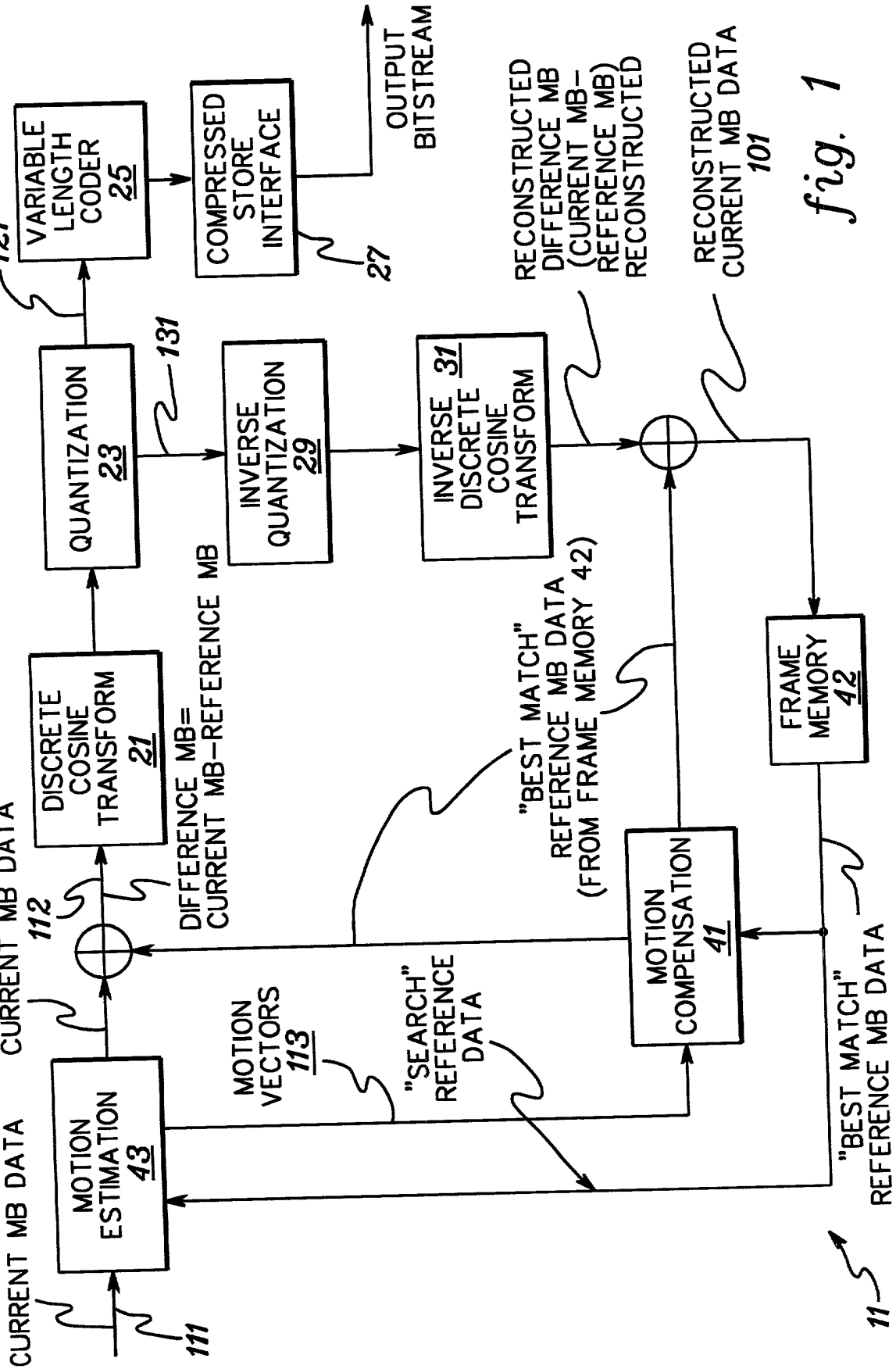
CURRENT MB DATA
111
MOTION ESTIMATION 43
CURRENT MB DATA
112
DISCRETE COSINE TRANSFORM 21
DIFFERENCE MB= CURRENT MB–REFERENCE MB
121
VARIABLE LENGTH CODER 25
COMPRESSED STORE INTERFACE
27
OUTPUT BITSTREAM
QUANTIZATION 23
131
INVERSE QUANTIZATION 29
INVERSE 31 DISCRETE COSINE TRANSFORM
RECONSTRUCTED DIFFERENCE MB (CURRENT MB–REFERENCE MB) RECONSTRUCTED
RECONSTRUCTED CURRENT MB DATA 101
"BEST MATCH" REFERENCE MB DATA (FROM FRAME MEMORY 42)
FRAME MEMORY 42
MOTION VECTORS 113
"SEARCH" REFERENCE DATA
MOTION COMPENSATION 41
"BEST MATCH" REFERENCE MB DATA
11

fig. 1

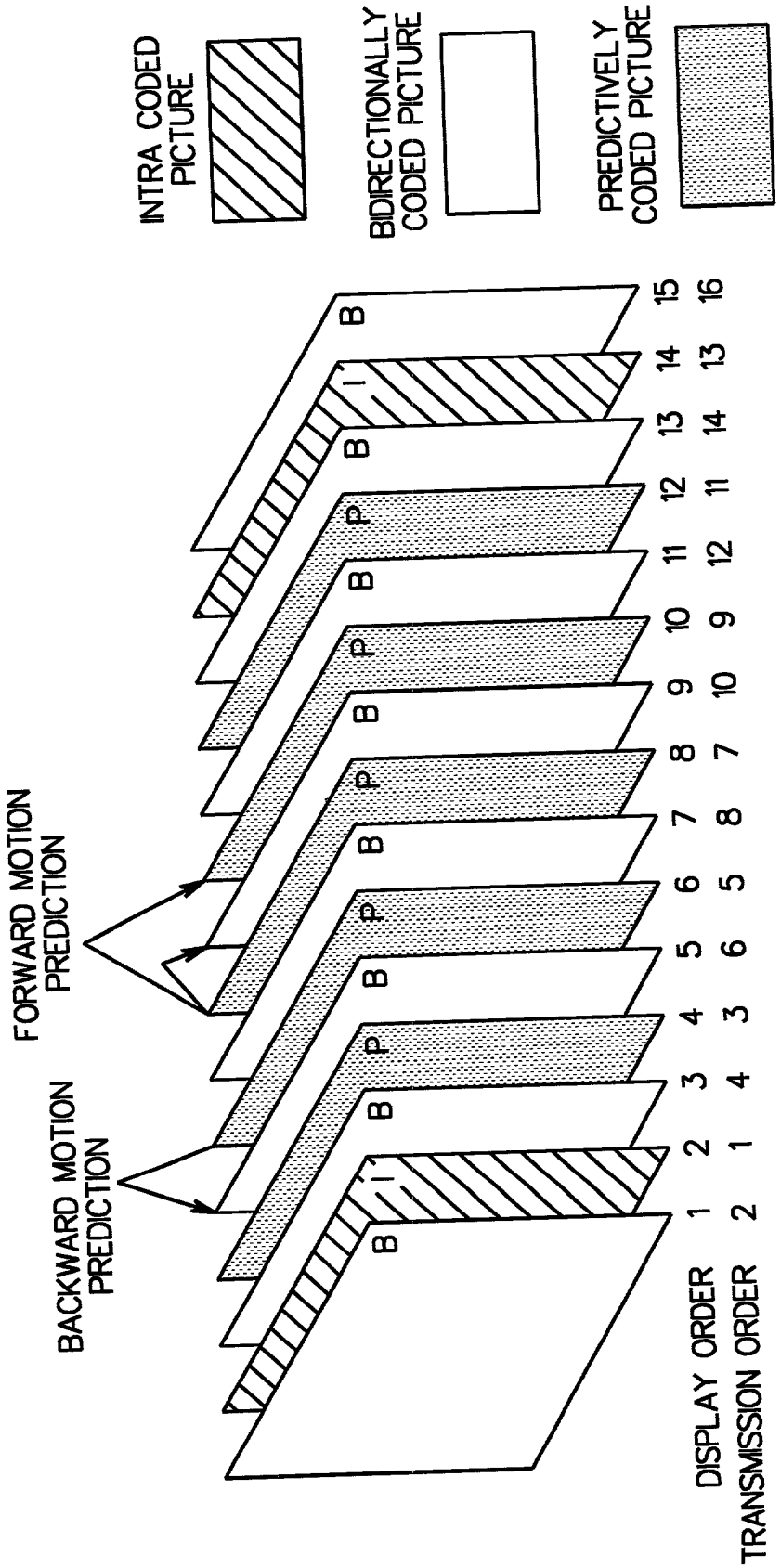
INTRA CODED PICTURE
BIDIRECTIONALLY CODED PICTURE
PREDICTIVELY CODED PICTURE
FORWARD MOTION PREDICTION
BACKWARD MOTION PREDICTION
DISPLAY ORDER
TRANSMISSION ORDER
I B B P B B P B B P B B P B B I B B
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16
2 1 4 3 6 5 8 7 10 9 12 11 14 13 16 15

fig. 2

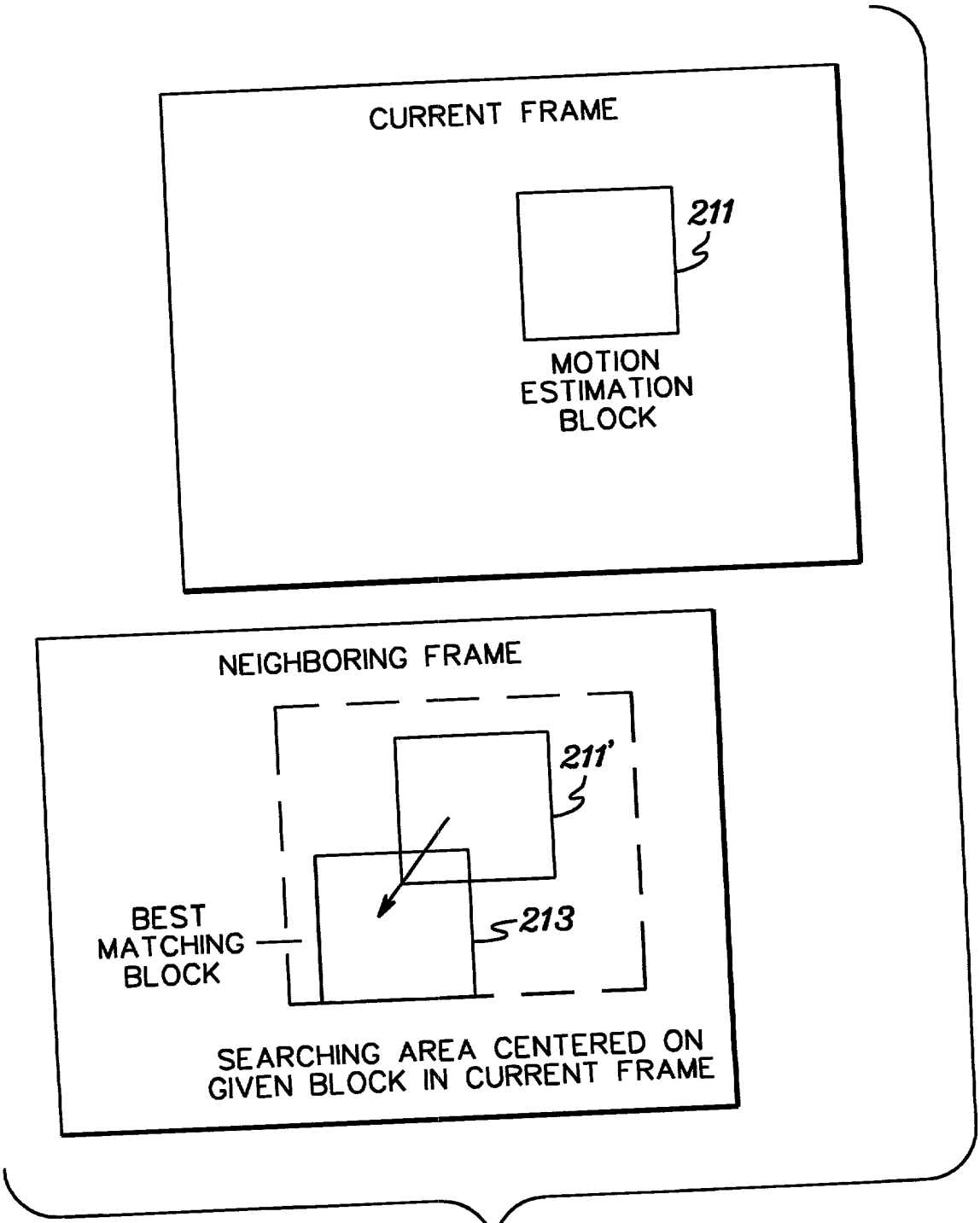
CURRENT FRAME
211
MOTION ESTIMATION BLOCK
NEIGHBORING FRAME
211'
213
BEST MATCHING BLOCK
SEARCHING AREA CENTERED ON GIVEN BLOCK IN CURRENT FRAME

fig. 3

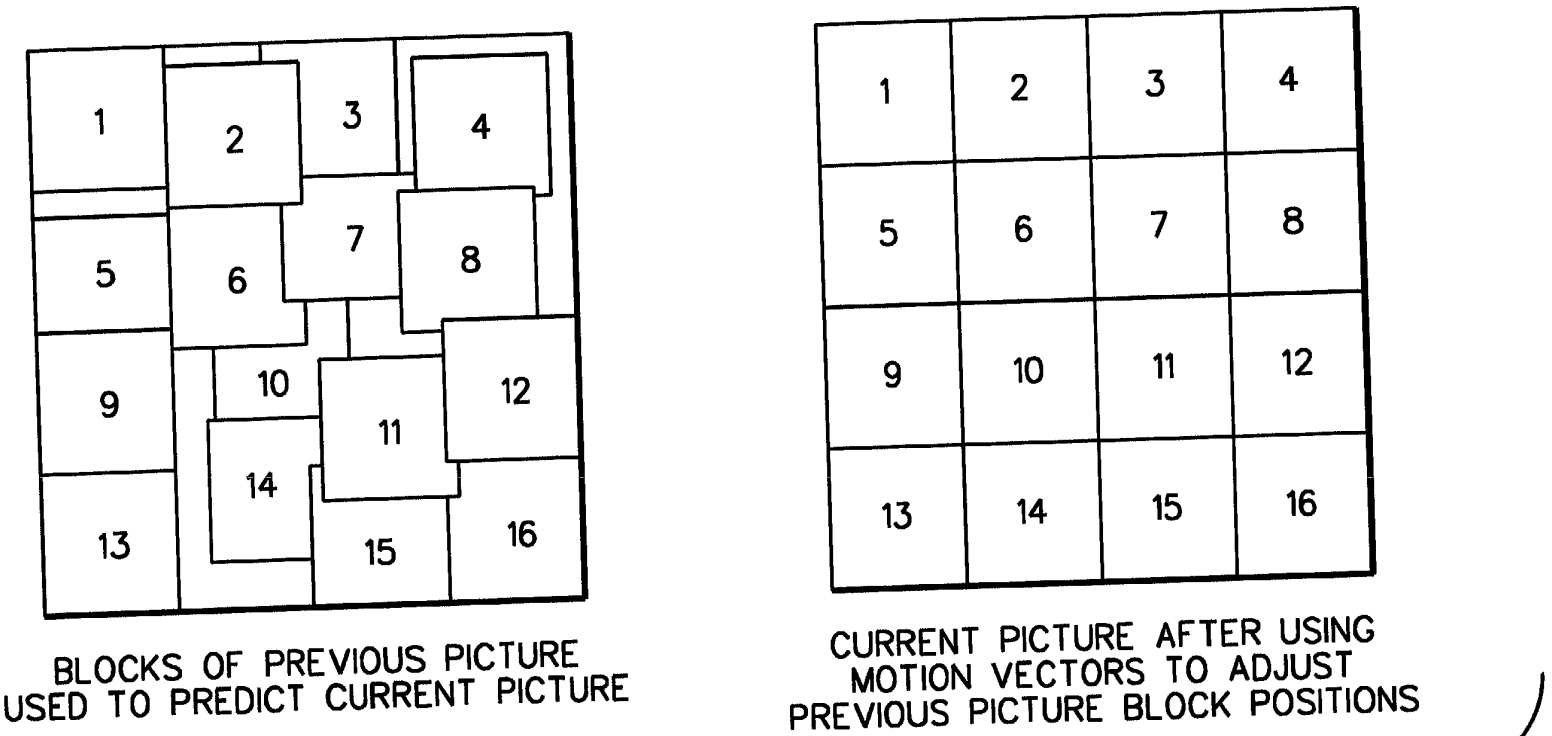
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
BLOCKS OF PREVIOUS PICTURE USED TO PREDICT CURRENT PICTURE
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
CURRENT PICTURE AFTER USING MOTION VECTORS TO ADJUST PREVIOUS PICTURE BLOCK POSITIONS

fig. 4

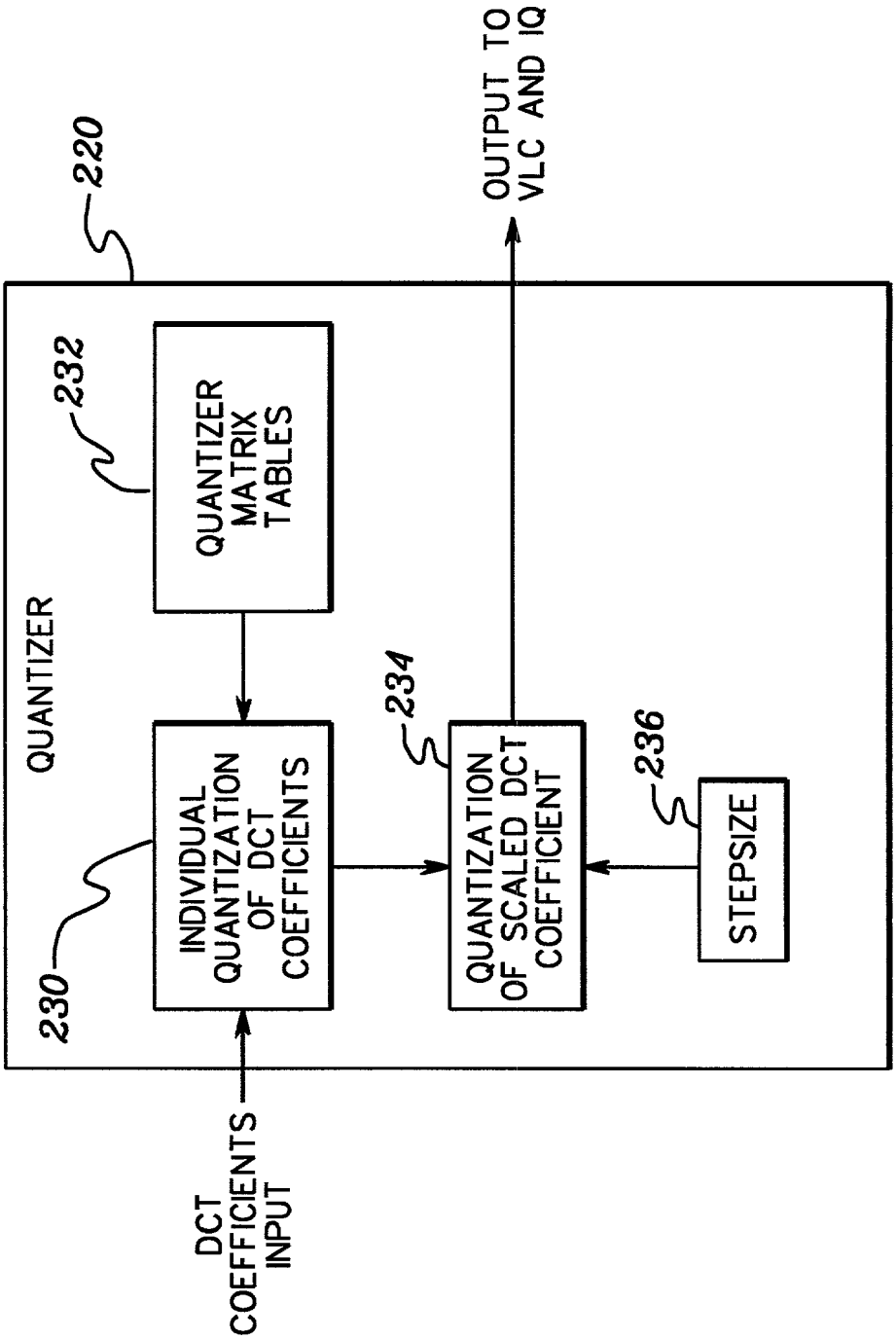
220
OUTPUT TO VLC AND IQ
QUANTIZER
232
QUANTIZER MATRIX TABLES
234
INDIVIDUAL QUANTIZATION OF DCT COEFFICIENTS
QUANTIZATION OF SCALED DCT COEFFICIENT
236
STEPSIZE
230
DCT COEFFICIENTS INPUT

fig. 5

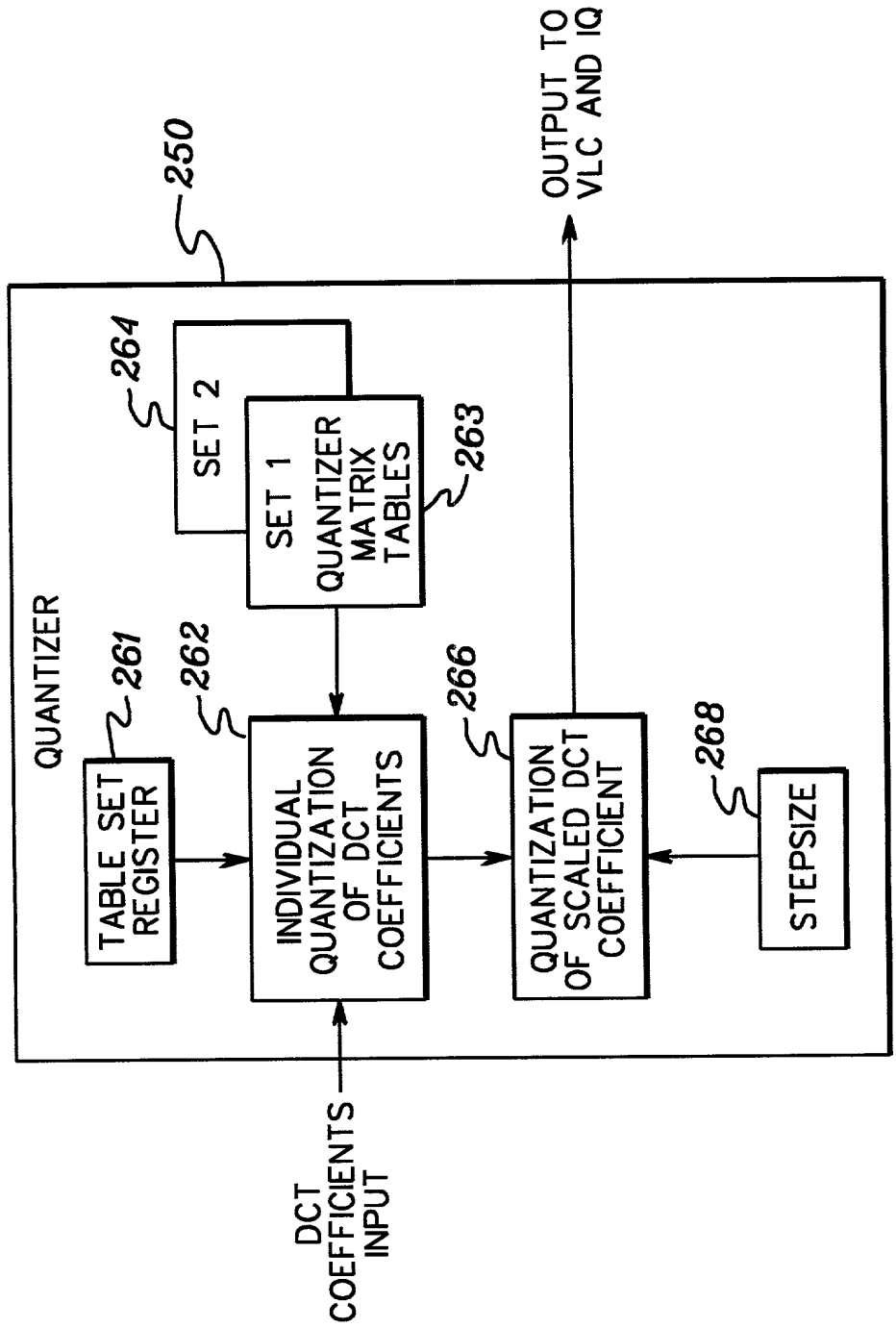
250
OUTPUT TO VLC AND IQ
QUANTIZER
264
SET 2
SET 1 QUANTIZER MATRIX TABLES
263
261
262
266
268
TABLE SET REGISTER
INDIVIDUAL QUANTIZATION OF DCT COEFFICIENTS
QUANTIZATION OF SCALED DCT COEFFICIENT
STEPSIZE
DCT COEFFICIENTS INPUT

fig. 6

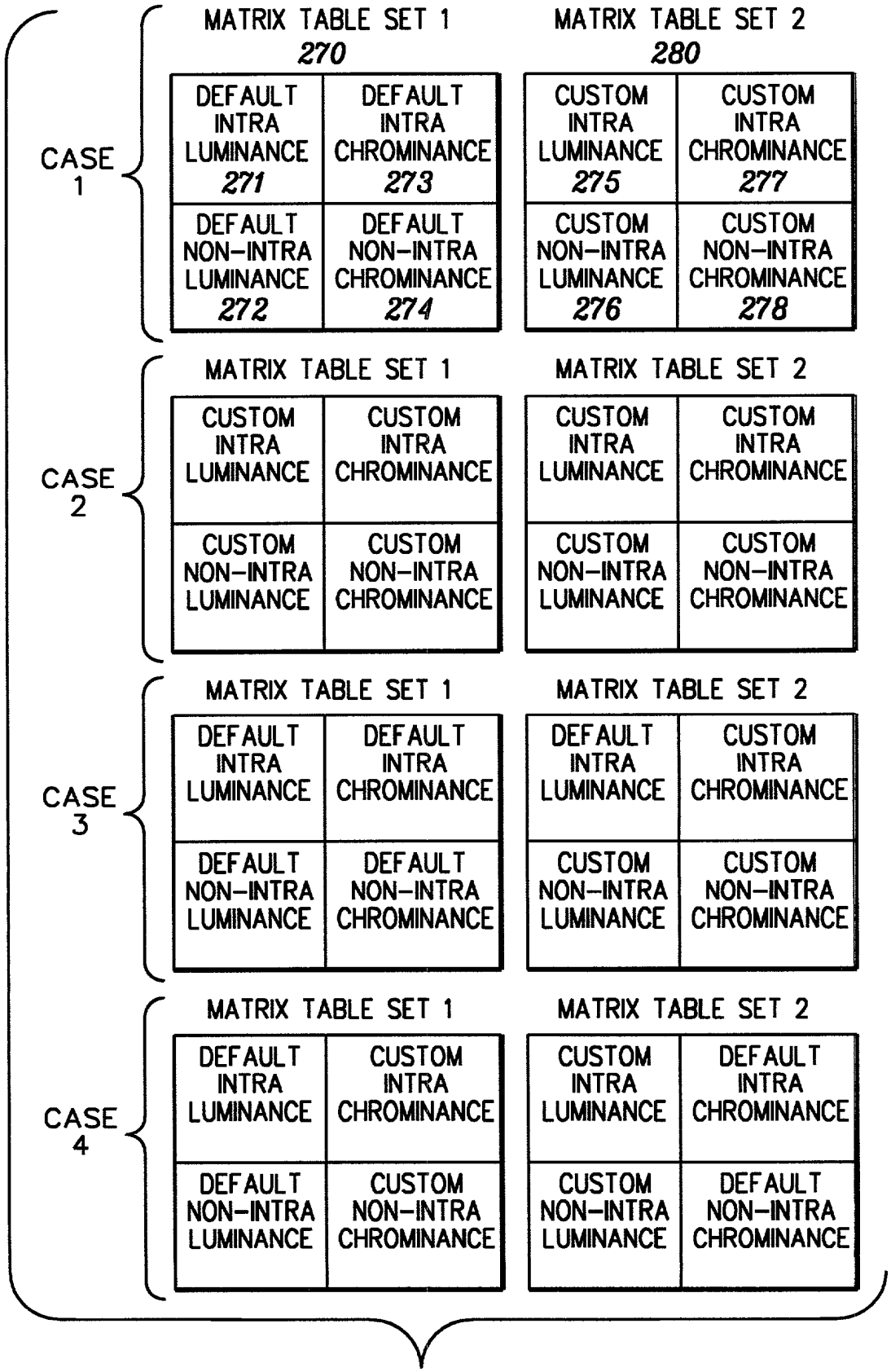
CASE 1
MATRIX TABLE SET 1
270
DEFAULT INTRA LUMINANCE 271
DEFAULT INTRA CHROMINANCE 273
DEFAULT NON-INTRA LUMINANCE 272
DEFAULT NON-INTRA CHROMINANCE 274
MATRIX TABLE SET 2
280
CUSTOM INTRA LUMINANCE 275
CUSTOM INTRA CHROMINANCE 277
CUSTOM NON-INTRA LUMINANCE 276
CUSTOM NON-INTRA CHROMINANCE 278
CASE 2
MATRIX TABLE SET 1
CUSTOM INTRA LUMINANCE
CUSTOM INTRA CHROMINANCE
CUSTOM NON-INTRA LUMINANCE
CUSTOM NON-INTRA CHROMINANCE
MATRIX TABLE SET 2
CUSTOM INTRA LUMINANCE
CUSTOM INTRA CHROMINANCE
CUSTOM NON-INTRA LUMINANCE
CUSTOM NON-INTRA CHROMINANCE
CASE 3
MATRIX TABLE SET 1
DEFAULT INTRA LUMINANCE
DEFAULT INTRA CHROMINANCE
DEFAULT NON-INTRA LUMINANCE
DEFAULT NON-INTRA CHROMINANCE
MATRIX TABLE SET 2
DEFAULT INTRA LUMINANCE
CUSTOM INTRA CHROMINANCE
CUSTOM NON-INTRA LUMINANCE
CUSTOM NON-INTRA CHROMINANCE
CASE 4
MATRIX TABLE SET 1
DEFAULT INTRA LUMINANCE
CUSTOM INTRA CHROMINANCE
DEFAULT NON-INTRA LUMINANCE
CUSTOM NON-INTRA CHROMINANCE
MATRIX TABLE SET 2
CUSTOM INTRA LUMINANCE
DEFAULT INTRA CHROMINANCE
CUSTOM NON-INTRA LUMINANCE
DEFAULT NON-INTRA CHROMINANCE

fig. 7

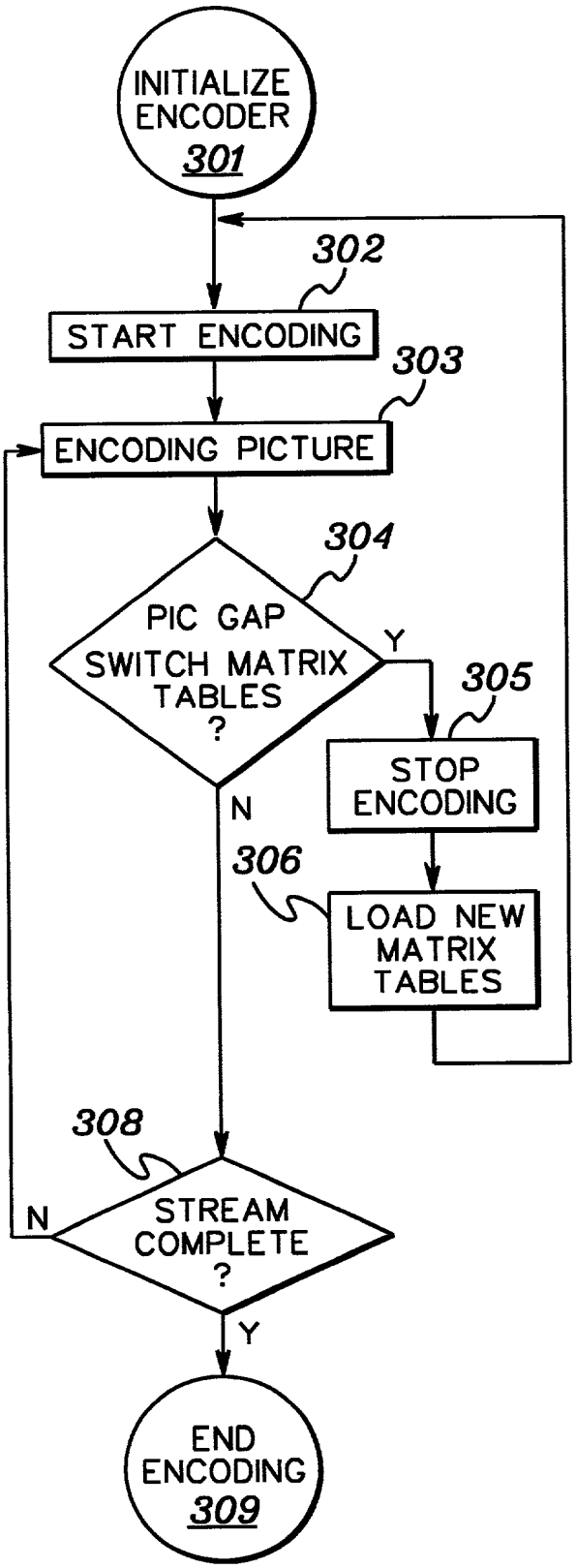
INITIALIZE ENCODER
301
302
START ENCODING
303
ENCODING PICTURE
304
PIC GAP SWITCH MATRIX TABLES ?
Y
N
305
STOP ENCODING
306
LOAD NEW MATRIX TABLES
308
STREAM COMPLETE ?
N
Y
END ENCODING
309

fig. 8a

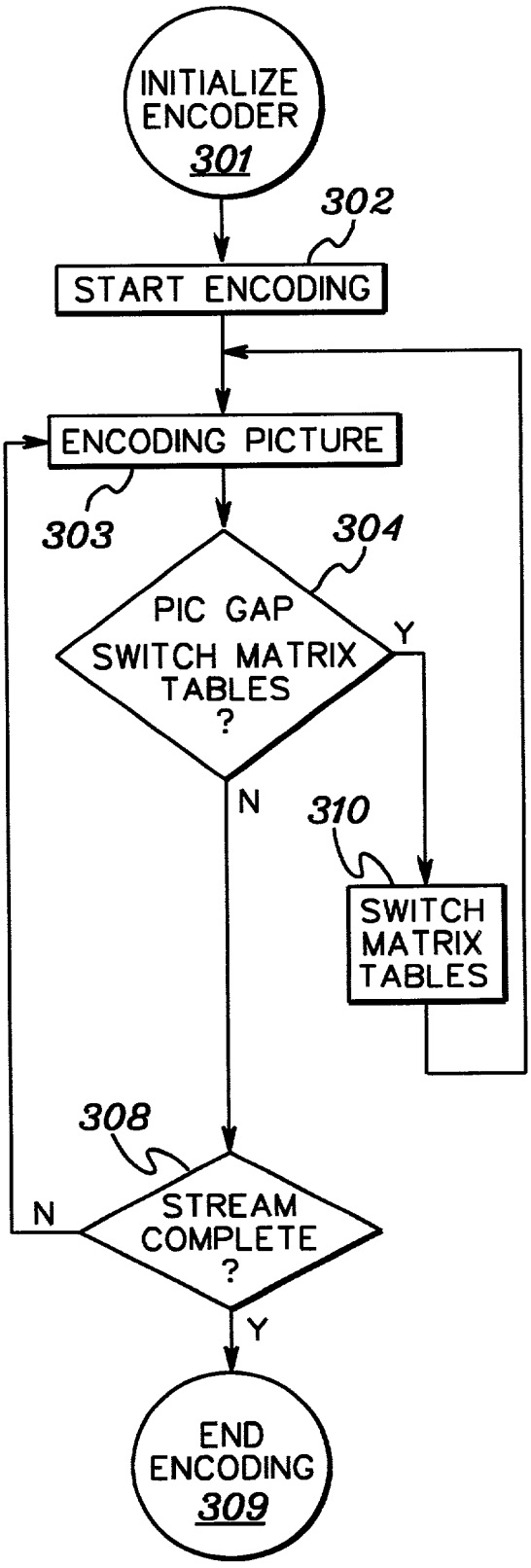
INITIALIZE ENCODER
301
302
START ENCODING
303
ENCODING PICTURE
304
PIC GAP SWITCH MATRIX TABLES ?
Y
N
310
SWITCH MATRIX TABLES
308
STREAM COMPLETE ?
N
Y
END ENCODING
309

fig. 8b

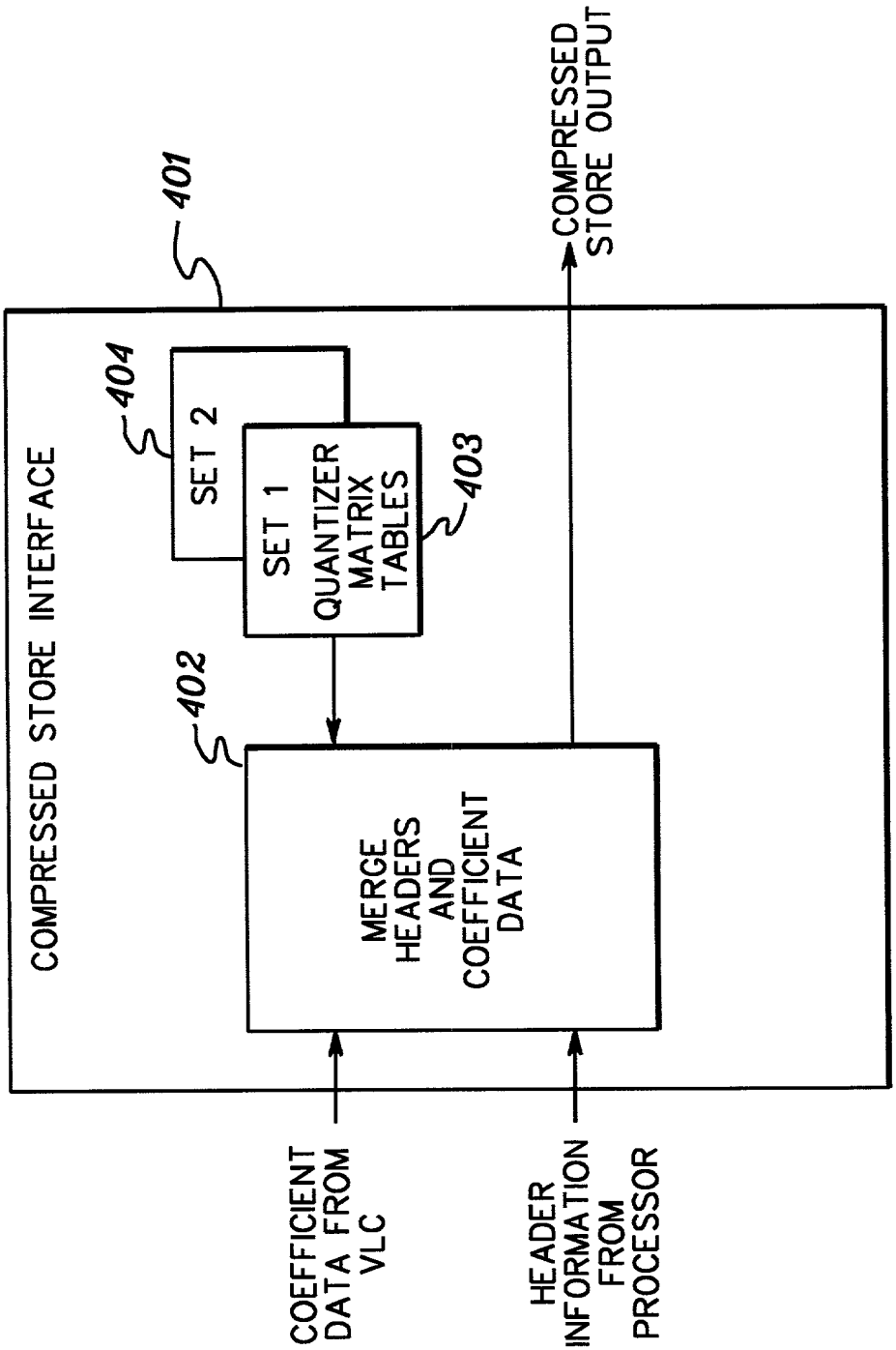
401
COMPRESSED STORE INTERFACE
404
SET 2
SET 1
QUANTIZER MATRIX TABLES
403
402
MERGE HEADERS AND COEFFICIENT DATA
COMPRESSED STORE OUTPUT
COEFFICIENT DATA FROM VLC
HEADER INFORMATION FROM PROCESSOR

fig. 9

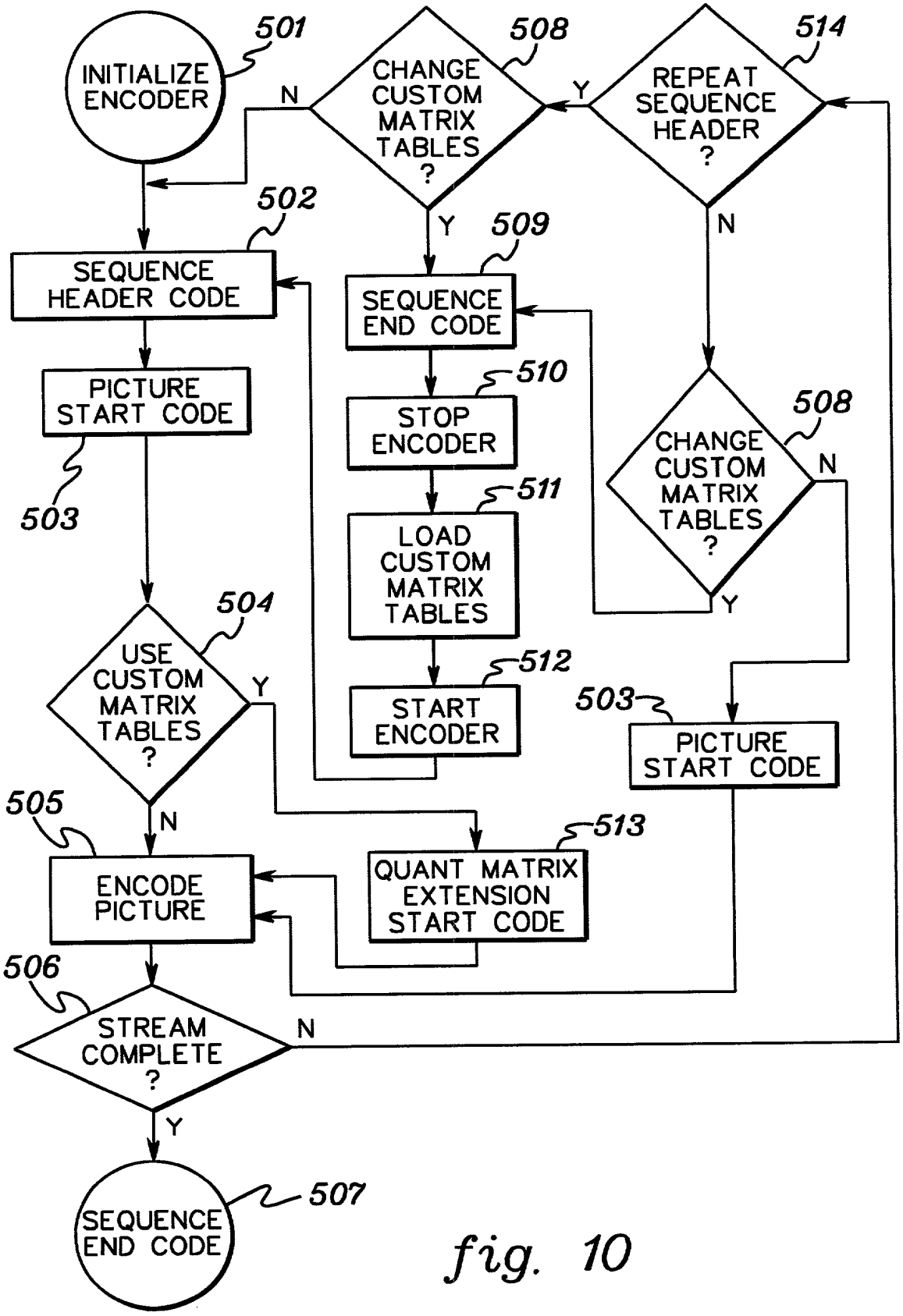
501
INITIALIZE ENCODER
508
CHANGE CUSTOM MATRIX TABLES ?
514
REPEAT SEQUENCE HEADER ?
N
Y
Y
N
502
SEQUENCE HEADER CODE
509
SEQUENCE END CODE
PICTURE START CODE
503
510
STOP ENCODER
511
LOAD CUSTOM MATRIX TABLES
512
START ENCODER
508
CHANGE CUSTOM MATRIX TABLES ?
N
Y
504
USE CUSTOM MATRIX TABLES ?
Y
N
503
PICTURE START CODE
505
ENCODE PICTURE
513
QUANT MATRIX EXTENSION START CODE
506
STREAM COMPLETE ?
N
Y
507
SEQUENCE END CODE

fig. 10

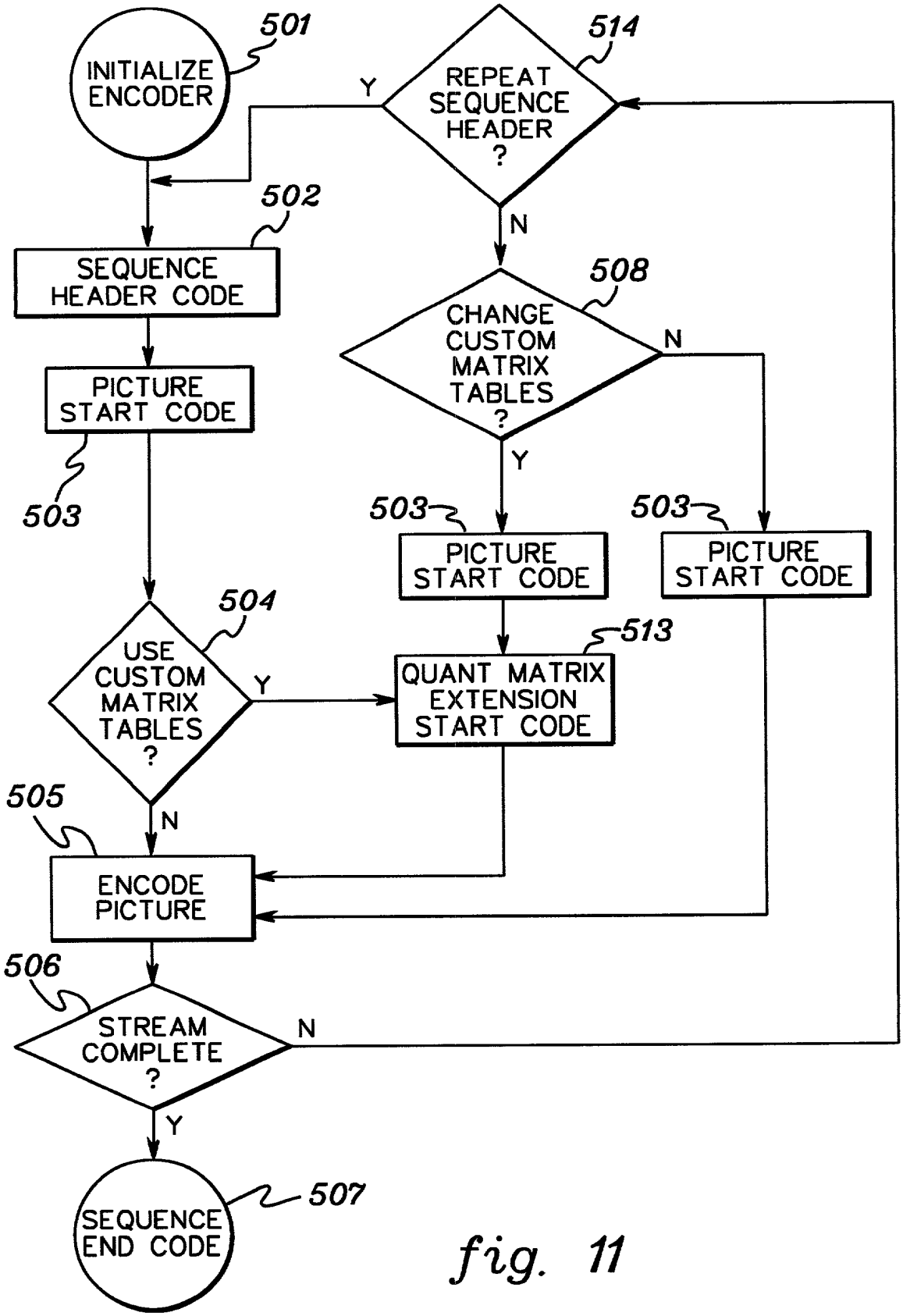
501
INITIALIZE ENCODER
514
REPEAT SEQUENCE HEADER ?
Y
N
502
SEQUENCE HEADER CODE
508
CHANGE CUSTOM MATRIX TABLES ?
N
Y
PICTURE START CODE
503
503
PICTURE START CODE
503
PICTURE START CODE
504
USE CUSTOM MATRIX TABLES ?
Y
513
QUANT MATRIX EXTENSION START CODE
505
N
ENCODE PICTURE
506
STREAM COMPLETE ?
N
Y
SEQUENCE END CODE
507

fig. 11

EXPRESS MAIL LABEL NO. EM589154154US

DOCKET NO. EN998082

DECLARATION AND POWER OF ATTORNEY FOR PATENT APPLICATION

As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below next to my name. I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled:

DYNAMICALLY SWITCHING QUANT MATRIX TABLES WITHIN AN MPEG-2 ENCODER

the specification of which (check one)

__X__ is attached hereto.

_____ was filed on _____ as United States Application Number or PCT International Application Number _____ and was amended on _____.

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment referred to above. I acknowledge the duty to disclose to the U.S. Patent and Trademark Office all information known to me to be material to patentability as defined in 37 CFR § 1.56.

I hereby claim foreign priority benefits under 35 U.S.C. § 119(a)-(d) or § 365(b) of any foreign application(s) for patent or inventor's certificate, or § 365(a) of any PCT International application which designated at least one country other than the United States, listed below and have also identified below any foreign application for patent or inventor's certificate, or PCT International application having a filing date before that of the application on which priority is claimed.

			Priority Claimed	
_____ (Number)	_____ (Country)	_____ (Day/Month/Year Filed)	___ Yes	___ No
_____ (Number)	_____ (Country)	_____ (Day/Month/Year Filed)	___ Yes	___ No

I hereby claim the benefit under 35 U.S.C. §119(e) of any United States provisional application(s) listed below.

_____ (Application Number)	_____ (Filing Date)
_____ (Application Number)	_____ (Filing Date)

I hereby claim the benefit under 35 U.S.C. § 120 of any United States application(s), or § 365(c) of any PCT International application designating the United States, listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States or PCT International application in the manner provided by the first paragraph of 35 U.S.C. § 112, I acknowledge the duty to disclose material information as defined in 37 CFR §1.56(a) which occurred between the filing date of the prior application and the national or PCT International filing date of this application:

(Appl. Serial No.)	(Filing Date)	(Status)(patented, pending, abandoned)
(Appl. Serial No.)	(Filing Date)	(Status)(patented, pending, abandoned)

POWER OF ATTORNEY: As a named inventor, I hereby appoint the following attorney(s) and/or agent(s) to prosecute this application and transact all business in the Patent and Trademark Office connected therewith:

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I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

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